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GEOPHYSICS.—*Some recent progress in isostatic investigations.*[1] WILLIAM BOWIE, Chief, Division of Geodesy, U. S. Coast and Geodetic Survey.

The theory of isostasy seems to be gaining in favor with geophysicists and geologists. This is shown by the progress made during the past year or two.

The holding of a symposium on isostasy by the Geological Society at its annual meeting at Amherst, Massachusetts, in December, 1921, indicated the interest which geologists are taking in the subject.

At the symposium, the papers presented covered a wide field. Nearly all of them attempted to show some relation of isostasy to geological problems and phenomena. The papers appeared in the June, 1922, number of the Proceedings of the Geological Society of America.

At the meeting of the Society in December, 1922, held at Ann Arbor, Michigan, there were a number of papers in which isostasy was given some consideration.

One of the most valuable additions to isostatic literature is "The Strandflat and Isostasy," by Fridjhof Nansen, published in "I Kommission Hos Dybwad," in December, 1922. In this book of more than 300 pages, the author shows that the isostatic balance was maintained almost, if not perfectly, in Norway during the loading of the area by ice-caps and after their disappearances. He makes out a strong case for isostasy which should be considered by those studying the processes operating in the earth's crust.

In addition to the papers referred to above, several others have appeared in Italy and the United States.

At the meeting of the Section of Geodesy, of the International Geodetic and Geophysical Union, held at Rome, Italy, in May, 1922, isostasy was given some consideration. Efforts are now being made

[1] Presented at meeting of the Section of Geodesy of the American Geophysical Union, at Washington, D. C., April 19, 1923. Received June 8, 1923.

to bring the subject before the geodesists of the countries adhering to the Union with a view to having it considered in detail at the meeting of the Geodetic Section which will be held at Madrid, Spain, in 1924. At that meeting it is hoped some definite plan may be adopted for applying the theory of isostasy to the treatment of gravity and deflection of the vertical stations. It is very desirable that uniformity in the treatment be agreed to by the several countries.

The field work done in the United States by the Coast and Geodetic Survey during the year, which can be used in isostatic investigations, consists of astronomic observations for latitude, longitude, and azimuth at triangulation stations, and the establishment of gravity stations.

The locations of eighteen of the gravity stations were selected by Dr. David White of the U. S. Geological Survey with a view to testing the effect on the value of gravity of variations from normal density in the material near the stations. The computation and adjustment of the observations made have been completed, and the results furnished to Dr. White. He expects to make an analysis of the data in the immediate future.

There are a number of localities in the United States where there are gravity stations close together which show great differences in the anomalies in very short distances. In the vicinity of Puget Sound the gravity anomaly at the Seattle station is -0.093 dyne, while at a point 15 miles to the westward the anomaly is only -0.025 dyne, and at a distance of 20 miles to the northwest of Seattle the anomaly is $+0.002$ dyne. At Tacoma, 27 miles south of Seattle, the anomaly is -0.012 dyne, and at Olympia, 50 miles to the southwest, the anomaly is $+0.033$ dyne.

There is an anomaly of $+0.059$ dyne at Minneapolis, while at Baldwin about 40 miles east of that place the anomaly is -0.050 dyne. At Damon Mound, in Texas, the difference in anomaly at two stations only seven miles apart, is 0.035 dyne. At Compton, California, the anomaly is -0.050 dyne while at two stations within 11 miles of Compton the anomalies are much less.

When it is considered that an anomaly of 0.001 dyne will be caused by the attraction of a disc of material of indefinite horizontal extent and 30 feet in thickness, we can realize that the differences in anomalies at some of the groups of stations in the United States represent the positive or negative attraction of large masses of material. It is certain that the cause of these differences in the anomalies must be in the upper part of the crust very close to the stations. If the causes

were deep-seated or were the lack of isostatic balance of the earth's crust near the groups of stations, there would not be such decided differences in the anomalies.

The accumulated geodetic data seem to indicate very clearly that the causes of large gravity anomalies are very local and probably are masses of extra light or extra heavy material close to the gravity stations. This being the case, we must conclude that the earth's crust is in a more nearly perfect state of equilibrium than has previously been supposed.

Late in 1921, eight gravity stations were established on or near the Mississippi River Delta in order to test the isostatic equilibrium of the earth's crust under the delta. A station already existed at New Orleans.

The average anomaly with regard to sign at eight stations on the delta is -0.007 dyne. Four of the anomalies are negative and four positive. The results seem to indicate already that the crust under the delta is in isostatic equilibrium and that the delta material is not an extra load on the crust. The average negative anomaly is due to the presence of abnormally light materials near the gravity stations. This conclusion is opposed to that of Barrell. He believed a study of the deltas of the rivers Niger and Nile showed them to be extra loads.[2]

It is hoped that gravity stations may be established on other well defined deltas for there is no better geological formation on which to test the theory of isostasy.

The really important problem in isostasy today is the use of the theory in geological research. The theory is widely accepted, but there still remains much confusion even in the minds of many of its advocates. Some claim too much for it while others do not give it sufficient credit.

The geodetic data in the form of values of gravity and the deflections of the vertical are facts. So also are the computed effects of topography. From these data we arrive at conclusions as to the isostatic condition of the earth's crust. These conclusions cannot be classed as mere speculations for they are based on logical processes of reasoning. Of course, assumption must be made as to the distribution of the isostatic compensation horizontally and vertically from topographic features. But even here there is evidence that the distribution probably takes place within certain limiting distances. One of the results of the acceptance of the theory of isostasy will be the

[2] *The strength of the earth's crust*, by Joseph Barrell, Journal of Geology, January–February, 1914.

modification of certain theories relating to crustal movements which were advanced before the theory of isostasy had been quantitatively studied.

SPECTROSCOPY.—*Regularities in the arc spectrum of titanium.*[1] C. C. KIESS and HARRIET K. KIESS, Bureau of Standards. (Communicated by Dr. W. F. MEGGERS.)

Until recently our knowledge of the series regularities occurring in spectra extended only to the elements hydrogen and helium, those of the first three columns of the periodic classification, and also the elements oxygen, sulphur and selenium of the sixth column. The more complex spectra of the elements occupying columns IV to VIII have for the most part remained unresolved. The extension of our knowledge of spectra into hitherto unexplored regions, the successful explanation of known spectrum regularities on the basis of modern atomic theories, and the recent discovery of new types of regularities in complex spectra have all inspired new attacks on the more complex spectra with successful results for chromium[2] and molybdenum[3] of column VI, for manganese[4], of column VII, and for iron[5] of column VIII.

The element titanium, of atomic number 22, is a member of column IV of the periodic classification. Its arc spectrum is of importance in astrophysics, the titanium lines occurring in all classes of stellar spectra from Type A to Type M of the Harvard Classification. In the spectrum of the sun practically all the more intense arc lines of titanium were identified by Rowland[6] from wave length 3000 A up to approximately 6900 A, and by Meggers[7] from wave length 6900 A to 9000 A. According to Adams[8], 91 per cent of all the titanium lines lying between 4000 A and 7000 A are strengthened in sun-spot spectra.

The arc spectrum of titanium has been measured from wave-length 2400 A in the ultra-violet to 9700 A in the infra-red. In Kayser's *Handbuch*, vol. 6, is given a summary of all the wave-length data pub-

[1] Published by permission of the Director, Bureau of Standards. Received June 17, 1923.

[2] Ann. der Physik, IV, **69**: 147. 1922; Science, **56**: 666. 1922; Anales Españ. de Fis. y. Quim., **21**: 84. 1923.

[3] B. S. Sci. Papers, In press.

[4] Proc. Roy. Soc. London A **223**: 146. 1922.

[5] Journ. Wash. Acad. Sci. **13**: 243. 1923.

[6] Prelim. Table Solar Spectrum, Chicago, 1896.

[7] Publ. Allegheny Observ., **6**: 13. 1919.

[8] Astroph. Journ. **30**: 86. 1909.

lished up to the year 1912. Since that time have appeared measurements by Kiess and Meggers[9] describing the spectrum from 5500 A to 9700 A in international units, and interferometer measurements by Brown[10] of 118 lines between the limits 4263 A and 6261 A. The character of the spectrum as a function of the temperature of the source has been studied by King[11] who has given the temperature classification of all the arc lines from 3888 A to 7364 A. King[12] also studied the Zeeman effect for the titanium spark in approximately the same spectral regions.

It is the purpose of this note to describe regularities of complex type that have been found to occur among the arc lines of titanium. In describing similar complex groups which he found in the spectrum of manganese, Catalán[13] coined the name multiplet for them. The multiplets of titanium are characterized by two different sets of recurring constant frequency differences. The differences 170.1 and 216.7 link together groups of six and seven lines similar to those found by Popow, Götze, Lorenser and others[14] in the spectra of the alkaline earths and of some of the elements of column III. The differences 42.0, 62.3, 81.7 and 100.2 occur in more complex groups of 11 and of 13 lines similar to the multiplets of manganese,[15] or those of chromium[16] and molybdenum.[17]

The majority of the lines so far classified belong to King's temperature classes I and II, although some of classes III and IV have been assigned to multiplets. It is worth while to remark here that the temperature classification of spectrum lines is an invaluable aid in unravelling complex spectra, furnishing clues which lead readily to the sought-for regularities. In each of the following groups the wave-lengths of the lines are followed by parentheses in which the arabic numeral gives the arc intensity of the line as taken from published data, and the Roman numeral gives the temperature class of the line. Beneath the wave-length is printed the wave-number of the line corrected to vacuum. The italicized numbers give the frequency differ ences occurring between the connected pairs of lines.

[9] B.S. Sci. Papers, **16**: 51. 1920.
[10] Astroph. Journ. **56**: 53. 1922.
[11] Astroph. Journ. **39**: 139. 1914.
[12] Astroph. Journ. **29**: 76. 1909; also **30**: 1. 1909.
[13] Proc. Roy. Soc. London, *A* **223**: 146. 1922.
[14] Paschen-Götze, Seriengestze, Berlin, 1922.
[15] Loc. cit.
[16] Ann. der Physik, IV **69**: 147. 1922, Anales Españ. de Fis. y Quim. **21**: 84. 1923.
[17] B. S. Sci. Papers, In press.

Multiplets in the arc spectrum of titanium:

Group 1.

	5152.18 (4I)	5210.39 (6I)
	19403.87 *216.79*	19187.08
	152.41	*152.40*
5147.49 (4I)	5192.97 (6I)	5252.11 (2I)
19421.55 *170.09*	19251.46 *216.78*	19034.68
98.55	*98.66*	
5173.74 (6I)	5219.72 (2I)	
19323.00 *170.20*	19152.80	

Group 2.

	3964.27 (7II)	3998.64 (10II)
	25218.20 *216.76*	25001.44
	161.14	*161.04*
3962.86 (7II)	3989.77 (10II)	4024.57 (8II)
25227.17 *170.11*	25057.06 *216.66*	24840.40
124.63	*124.44*	
3982.54 (5II)	4009.68 (4II)	
25102.54 *169.98*	24932.62	

Group 3.

	3914.33 (7II)	
	25539.98	
	216.21	
3921.42 (5II)	3947.75 (8II)	3981.77 (8II)
25493.76 *169.99*	25323.77 *216.38*	25107.39
54.74	*54.65*	
3929.86 (6II)	3956.28 (10II)	
25439.02 *169.90*	25269.12	

Group 4.

3717.39 (5)	3741.06 (6)	3771.64 (4)
26893.00 *170.18*	26722.82 *216.67*	26506.15
118.09	*118.16*	
3733.78 (2)	3757.68 (3)	
26774.91 *170.25*	26604.66	
52.66		
3741.14 (5)		
26722.25		

Group 5.

	3642.68 (10)	3671.66 (5)
	27444.56 *216.64*	27227.92
	134.54	*134.55*
3637.96 (3)	3660.62 (5)	3689.89 (5)
27480.16 *170.14*	27310.02 *216.65*	27093.37
62.10	*61.99*	
3646.19 (3)	3668.95 (5)	
27418.06 *170.03*	27248.03	

Group 6.

	2937.30 (8)	2956.13 (8)
	34034.90 *216.73*	33818.17
	126.36	*12.635*
2933.53 (8)	2948.25 (8)	2967.22 (10)
34078.64 *170.10*	33908.54 *216.72*	33691.82
97.98	*98.02*	
2941.99 (10)	2956.80 (10)	
33980.66 *170.14*	33810.52	

Group 7.

				*4981.73 (10II)
				20067.75
				137.71
			*4991.07 (9II)	5016.16 (4II)
			20030.21 *100.17*	19930.04
			115.53	*115.62*
		*4999.50 (9II)	5020.02 (5II)	5045.43 (2IIIA)
		19996.44 *81.76*	19914.68 *100.26*	19814.42
		93.01	*93.03*	
	*5007.21 (8II)	5022.86 (4II)	5043.59 (2IIIA)	
	19965.66 *62.23*	19903.43 *81.78*	19821.65	
	70.03	*70.15*		
*5014.28 (8II)	5024.83 (4II)	5040.63 (2IIIA)		
19937.52 *41.89*	19895.63 *62.35*	19833.28		
	45.97			
	5036.47 (4II)			
	19849.66			

* *Raies ultimes.*

Group 8.

			8267.62 (1)	
			12092.06	
			139.60	
		8307.41 (1)	8364.18 (2)	8434.89 (4)
		12034.14 *81.68*	11952.46 *100.19*	11852.27
		101.15	*101.25*	
	8334.42 (2)	8377.83 (2)	8435.64 (5)	
	11995.14 *62.15*	11932.99 *81.78*	11851.21	
	68.95	*68.86*		
8353.12 (2)	8382.61 (3)	8426.46 (4)		
11968.30 *42.11*	11926.19 *62.06*	11864.13		
	42.15			
	8412.34 (3)			
	11884.04			

Group 9.

			4512.73 (8II)	4533.25 (9II)
			22153.35 *100.30*	22053.05
			107.73	*107.63*
		4518.02 (8II)	4534.78 (9II)	4555.49 (7II)
		22127.42 *81.80*	22045.62 *100.20*	21945.42
		85.70	*85.56*	
	4522.80 (8II)	4535.58 (4II)	4552.45 (8II)	
	22104.04 *62.52*	22041.72 *81.66*	21960.06	
	63.97	*63.89*		
4527.31 (6II)	4535.92 (6II)	4548.77 (8II)		
22081.98 *41.91*	22040.07 *62.24*	21977.83		
42.30	*42.52*			
4536.00 (5II)	4544.69 (8II)			
22039.68 *42.13*	21997.55			

Group 10.

			4295.75 (5II)	43.14.34 (3III)
			23272.32 *100.30*	23172.02
			23.31	*23.02*
		4284.99 (4III)	4300.05 (4V)	4318.63 (5III)
		23330.74 *81.73*	23249.01 *100.01*	23149.00
		79.52	*79.46*	
	4288.18 (3III)	4299.64 (5III)	4314.80 (3II)	
	23313.39 *62.17*	23251.22 *81.67*	23169.55	

		251.03		*251.19*	
4326.98	(2III)	4334.86	(3III)	4346.60	(3IV)
23104.34	*41.98*	23062.36	*62.33*	23000.03	
405.49		*405.48*			
4404.28	(5III)	4412.44	(2III)		
22698.85	*41.97*	22656.88			

The lines which have thus far been classified are about 100 in number, or very nearly 10 per cent of the total recorded for the arc spectrum. Work is still in progress and it is hoped to present more complete details of the investigation in the Scientific Papers of the Bureau of Standards. The element zirconium, of atomic number 40, follows titanium in column IV of the periodic classification. We have found in its spectrum multiplets similar to some of those recorded below. We expect also to present the details of this investigation in the near future.

CHEMISTRY.—*The oxides of iron.*[1] JOHN B. FERGUSON, University of Toronto.

In spite of the large amount of work that has been done upon the problem of the oxides of iron, our knowledge of this subject is far from complete. In particular, diverse views are held as to the nature of the iron phase, the nature of the ferrous iron phase, and the proper values of the equilibrium constants in the system—(H_2,H_2O, Fe, FeO).[2] The present paper deals with these points.

I. THE IRON PHASE

Mixtures of hydrogen gas and water vapour at atmospheric pressure were passed over iron at high temperatures and the resultant degree of oxidation noted.

The charge was placed in a porcelain boat in an electrically heated tube furnace and the furnace swept out with oxygen-free nitrogen. The furnace was then brought up to temperature and the gas mixture admittted. At the end of the experiment, the gas mixture was swept out with the nitrogen and the charge allowed to cool. When it was cold it was removed and analyzed.

[1] Received May 23, 1923. The experimental work on which this paper is based was in part carried out by Messrs. Findlay, Robertson, Noble, Hoover and Mulligan. See *Transactions of the Royal Society of Canada*, **15**: 55. 1921; **16**: 273. 1922; and the volume for the current year.

[2] Fe and FeO are here used to designate the phases and are not meant to indicate the exact compositions of these phases.

Commerical hydrogen and nitrogen were used. Both were passed over hot copper to remove oxygen, and the nitrogen was in addition carefully dried. The purified hydrogen contained not over 0.2 per cent of nitrogen and allowance was made for this in the calculations.

The gas mixtures were prepared by passing the hydrogen through wash bottles, containing distilled water, immersed in an electrically controlled thermostat.

Electrically heated connecting tubes prevented the water from condensing out of the gas mixture prior to its reaching the hot zone of the furnace.

TABLE I.—EXPERIMENTS ON THE NATURE OF THE IRON PHASE

EXPERIMENT NUMBER	TEMPERATURE DEG. C.	TIME, HOURS	RATIO H_2O/H_2	IRON CONTENT, PER CENT		REMARKS
				Initial	Final	
1	750	6	0.476	100	99.98	Pure iron
2	750	6	0.540	100	99.90	Pure iron
3	750	6	0.33	99.78	99.67	Piano wire
4	980	6	0.44	100	99.86	Pure iron
5	960	6.5	0.44	100	100.1	Pure iron
6	960–80	6	0.44	98.88	99.84	Oxidized iron

A carefully calibrated thermoelement and a potentiometer served for the temperature measurements.

The initial and final products were analyzed for total iron. Both the usual permanganate method and the dichromate electrometric method were employed.[3]

The pure iron was an electrolytic product which had been reduced for many hours at 900°–1000°C. with dry hydrogen. Permanganate titrations indicated 99.90 and 100.0 per cent iron while dichromate gave 100.1 and 99.95 per cent. It contained no manganese and less than 0.05 per cent carbon.

The results of the best controlled experiments are given in table I.

The first five experiments do not indicate that pure iron will take up oxygen to form solid solutions. One might say, however, that such solutions are stable but that their rate of formation is such that they did not have time to form. This hypothesis seems improbable but was worth checking. Experiments at 750°C. afforded no information on this point. Even with dry hydrogen, a slightly oxidized iron sample

[3] Mr. Mulligan was unable to detect any difference between the oxidizing strengths of these solutions such as was recently reported to exist. *Journ. Am. Chem. Soc.* **44**: 2148. 1922.

could not be completely reduced though heated for many hours.[4] An experiment at a higher temperature was more successful. Experiment 6 shows that the hypothesis is untenable.

The results appear to be evidence in favour of the view[5] that in the (H_2H_2O, Fe, FeO) system, the iron phase contains no appreciable amount of oxygen but is practically pure iron.

II. THE FERROUS IRON PHASE

That ferrous oxide may take up ferro-ferric oxide in solution seems to be fairly well established.[6] The available equilibrium measurements[7] indicate that this ferrous oxide phase is unstable at low temperatures and Chaudron[8] has qualitatively checked this theoretical possibility. At 1100°C. Hilpert was able to prepare an iron-free ferrous oxide containing 1.5 per cent of ferric oxide but at 700°C. the ferrous oxide he obtained, free from metallic iron, contained some 15

TABLE II.—ANALYSES OF SAMPLES USED

SAMPLE	FREE IRON	FERROUS IRON	FERRIC IRON	TOTAL IRON	METHOD OF PREPARATION
I	Trace	78.16	21.84	76.03	750°C. H_2, H_2O
II	0.72	87.48	11.80		800°C. H_2, H_2O
III	Trace	84.65	15.35		920°C. CO, CO_2

per cent of the higher oxide. The synthetic experiments of Hilpert furnish the only information we have upon the relative stability of the ferrous oxide solid solutions. This question of relative stability seemed to us to merit further investigation.

We have prepared from pure iron, using suitable gas mixtures of hydrogen and water vapour, many samples intermediate in composition between FeO and Fe_3O_4. Two such samples and a third sample, made with a gas mixture of carbon monoxide and carbon dioxide, were selected as materials suitable for a study of the invariant point, at which the ferrous oxide and iron phases are in equilibrium with the

[4] Similar results are reported by Richards and Baxter. *Z. anorg. allgem. Chem.* **23**: 245. 1900.

[5] R. B. Sosman, This JOURNAL **7**: 56. 1917.

[6] Hilpert and Beyer, *Ber. deutsch. Chem. Ges.* **44**: 1908. 1911. Matsubara, *Trans. Am. Inst. Mining Met. Eng.*, reprint 1051, issued with Mining and Metallurgy, February, 1921.

[7] For a summary of these, see the paper by Eastman. *Journ. Am. Chem. Soc.* **44**: 975. 1922.

[8] Chaudron, *Annales de Chimie*, **16**: 221. 1921.

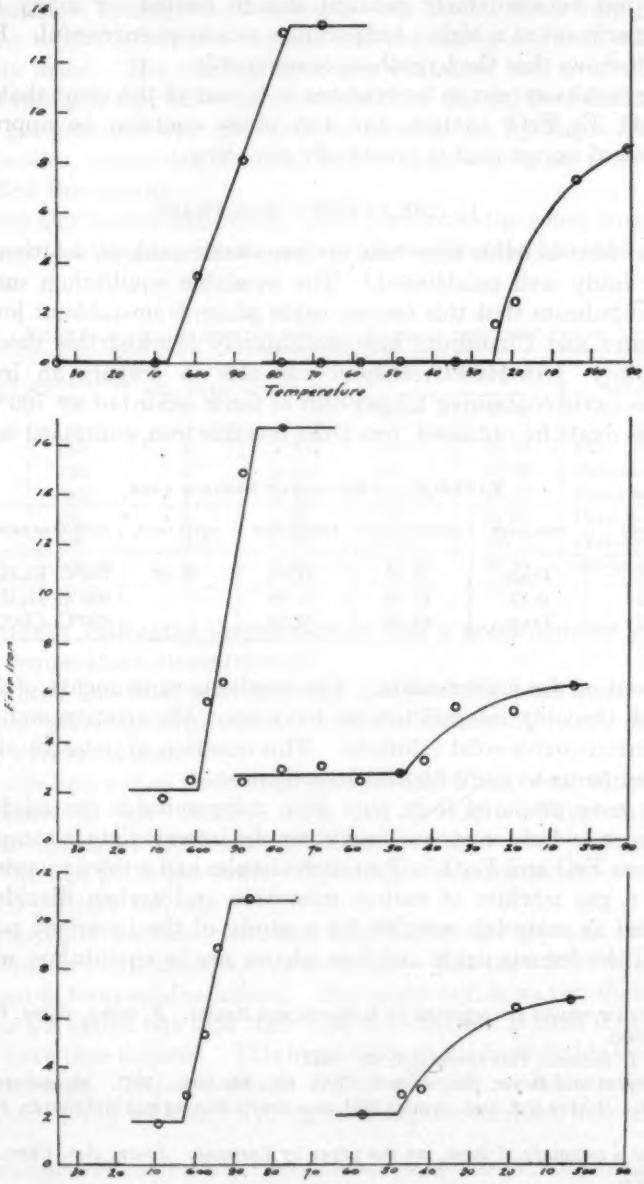

Fig. 1.

ferro-ferric oxide phase and vapor in the system, (Fe-O). Analyses of these samples are given in table II.

The free iron was determined by the copper sulfate method.[9] The ferrous iron reported was the value obtained by titration corrected for the metallic iron present. The ferric oxide was obtained by difference.

Each of these samples was divided into two parts. One part was kept and the other part was heated at a low temperature in vacuum until it contained an appreciable amount of free iron. We shall refer to this latter part as the converted part. Portions of each kind of material were then heated in vacuum in sealed pyrex glass tubes for five hours at carefully regulated temperatures. The free iron in each portion was then determined. The results are shown graphically in figure I. The graphs represent in order samples I, II, and III. The right hand curves were obtained with the original materials.

If all the ferrous oxide in samples I and II were converted to free iron and magnetic oxide, the resultant free iron content would be, respectively, 13.3 and 16.7 per cent. This calculation assumes the equation $4\ FeO \rightleftharpoons Fe + Fe_3O_4$. We were able to obtain conversions of 13.5 and 16.9 per cent iron and this is as good a check as one could expect from such materials.

With sample I, but one reaction appears to take place. Iron does not begin to form in the iron-free material until a temperature of 526°C. is reached. The iron in the converted part begins to combine at 577°C. and the reaction proceeds until all the free iron has combined.

With samples II and III, there appears to be an additional reaction by means of which a small quantity of iron is liberated. This may be noted even above 600°C. and the quantity of iron so formed does not appear to vary much in the temperature interval between this temperature and the temperature at which the major reaction takes place. The iron liberated in this reaction does not recombine when the converted materials are heated at the higher temperatures and the major reaction takes place.

Hilpert could not tell whether the compositions richer in ferrous oxide were unstable at the lower temperatures, or whether they were stable but could not be prepared owing to the slow reaction velocity. Our experiments indicate that they are not stable. It seems probable that ferrous oxide in the pure state is unstable at a fairly high temperature but that by the solution of ferro-ferric oxide the temperature of transition is lowered. The rates at which iron would form on cooling

[9] Williams and Anderson, *Journ. Ind. Eng. Chem.* 14: 1057. 1922.

ferrous oxide charges are such that its formation may have been a disturbing factor in Hilpert's work. The compositions of his iron-free ferrous oxide phases are probably richer in ferric iron than the phases which would be stable and in equilibrium with metallic iron at the various temperatures.

According to the hypothesis just advanced, the ferrous oxide solution saturated with ferro-ferric oxide would be the only one which would not partially decompose at temperatures above the invariant point. Matsubara's experiments indicate that in the range 863°–1175°C. the solubility is practically independent of the temperature. His saturated solution contains a little less than 76 per cent total iron. Sample I, which behaves as one would expect the saturated solution to do, contains 76.03 per cent iron.

The temperature of the invariant point must lie below 577°C. and above 526°C. Probably it lies much closer to the upper temperature rather than to the lower. More will be said regarding these temperatures later.

TABLE III.—EXPERIMENTS TO DETERMINE THE EQUILIBRIUM CONSTANT AT 750°C.

INITIAL MATERIAL	TIME HOURS	RATIO H_2O/H_2	IRON CONTENT PRODUCT	REMARKS
Pure iron	6	0.476	99.98	No oxidation
Pure iron	6	0.540	99.90	Oxidation slight if any
Pure iron	6	0.568	98.0	Oxidation started
			98.8	Analyses from different parts of the boat
Pure iron	6	0.595	93.6	More oxidation

III. THE EQUILIBRIUM CONSTANTS

A series of experiments was carried out at 750°C. and atmospheric pressure with the view of checking by the stream method the diverse values which have been obtained for the equilibrium constant by static methods. A similar apparatus to that used for the iron phase investigation was employed. Blank experiments were carried out in order to test the apparatus and method. The results are given in Table III.

These results indicate that oxidation starts with a mixture having a ratio probably slightly less than 0.54 and certainly less than 0.57. Chaudron's latest work leads to a value of 0.53 for this temperature. Eastman's calculated value would be 0.441. That of Schriener and Grimnes would be approximately 0.66.

Eastman has collected all the results to date on this equilibrium constant for various temperatures. A study of his graph of these shows that the results of Schriener and Grimnes give for the invariant point[10] a temperature of 636°C. Our work places this temperature below 577°C. and furnishes additional evidence that the constants of these workers are too large. It does not indicate, unfortunately, whether the values of Chaudron or of Eastman are to be preferred since one places the invariant point at 570° while the other gives it a value of 565°C.

Our stream method experiments give an upper limit for the constant. Since Chaudron was able to obtain good agreement between oxidation and reduction experiments at 785°C., we think that our value, which agrees with his, must be not far from the true value for the particular temperature.

The discrepancy between this value and that calculated by Eastman from the constants of the (CO_1CO_2,Fe,FeO) system arises from the fact that he gave great weight to the work of Matsubara. Chaudron's results on the two systems are in excellent agreement at 785°C. as evidenced by the fact that from them he obtained a value for the constant of the water-gas reaction of 0.87, Haber's value for this being 0.86. In view of this, one is somewhat at a loss as to how to interpret these results of Matsubara. Perhaps his iron phase was not the same as that found by us in the other system. His conclusion, that the iron phase contains much ferrous oxide in solution, though the most obvious one, is not the only possible explanation of his results and would seem to be in marked conflict with our own observations.

SUMMARY

1. The iron phase in the system (H_2,H_2O,Fe,FeO) does not contain appreciable quantities of oxygen.

2. The transition temperature of the ferrous oxide phase appears to be lowered by solution of ferro-ferric oxide in the ferrous oxide, The quadruple point lies below 577°C.

3. A value for the equilibrium constant at 750°C. was obtained by the stream method. It agrees with the value obtained by the interpolation from the results of Chaudron and furnishes a check on the latter.

[10] The temperature of the quadruple point in the system (Fe, O,H) may be considered for our purpose as identical with that of the invariant point in the system (Fe, O).

MINERALOGY.—*Methods for distinguishing natural from cultivated pearls.*[1] F. E. WRIGHT, Geophysical Laboratory.

Efforts have been made for several centuries to induce pearl-growing oysters and mussels to produce pearls comparable in quality and size to the "natural" or " normal" pearls found by pearl divers in different parts of the world and known to the trade as fine pearls. It is a simple matter to provoke formation of "blisters" and baroque pearls, but only recently has a Japanese, Dr. K. Mikimoto, succeeded in developing a suitable method for inducing pearl oysters to grow pearls which are spherical in shape and similar in external appearance to fine pearls. His process, which has been patented, is essentially the following: A pearl oyster is first removed from its shell; from its outer, shell-secreting mantle, a patch is dissected off, large enough to enclose, as a sac tied at the neck, a foreign nucleus, such as a bead of mother-of-pearl or even an inferior pearl. Each bead thus enveloped by the shell-secreting epidermis is embedded in the sub-epidermal tissues of another live oyster, which, after proper treatment of the wound, is returned to its native habitat where in the course of a few years a coating of pearl around the inserted bead may be deposited. The success of this process is due, as was first emphasized by Dr. H. Lyster Jameson,[2] to the "presence, in the sub-epidermal tissues of the oyster, of a closed sac of the shell-secreting epidermis and not to the presence of an irritating foreign body" as has been often supposed.

The pearls thus induced by the Mikimoto process are now on the market and pearl merchants have had difficulty in distinguishing natural Japanese pearls from the cultivated pearls of Mikimoto.

A short time ago the writer's interest in this problem was aroused by Dr. G. F. Kunz of New York who kindly loaned him, for examination and comparison, examples of the Japanese cultivated pearls and of fine pearls. In the Japanese pearls the centers were without exception mother-of-pearl beads, and the methods described below are based in large part on the ability of the observer to recognize the mother-of-pearl nucleus.

Mother-of-pearl or nacre substance is composed of alternate laminae or layers of calcium carbonate and of a horny organic substance called conchiolin. In most of the mother-of-pearl shells examined by the writer the carbonate is the mineral aragonite in the form of needles elongated parallel with the acute bisectrix and oriented perpendicular

[1] Received June 19, 1923.

[2] Proc. Zool. Soc., I, 140–166. 1902; Nature, Jan. 22, 1903, p. 280; Nature, May 26, 1921, p. 397.

to the pearly layers. The iridescence (luster, orient) of the pearl is due to interference of waves of light at the different pearly layers[3] which are remarkably uniform in thickness; the combined thickness of the carbonate layer and the conchiolin layer is 0.0004 to 0.0006 mm. or about equal to a wave length of light. At the surface of each layer some light is reflected and this interferes with a certain part of the incident light. The final result is the reflection of a relatively large amount of light and a correspondingly low transmission of the mother-of-pearl for rays of light incident normal to the pearly surface. The reflecting power on sections normal to the layers is appreciably less and the transmission is relatively much higher. This difference in reflecting power and in transparency with direction is easily seen on a bead of mother-of-pearl. Held in one position the characteristic pearly luster appears; turned through 90° the luster is less and the bead is noticeably more transparent. In strong sunlight this difference is still more striking. If now the bead of mother-of-pearl is enclosed in concentric layers of pearly substance, the lack of transparency of these layers, especially when viewed along a diametral direction, tends to mask the mother-of-pearl phenomena; but if the cultivated pearl be viewed under proper conditions of illumination the phenomena characteristic of mother-of-pearl are readily seen.

1. *Test in reflected light.* To test a pearl by this method examine the pearl first in reflected light. Stand with the back to the window, to the sun, or to some strong source of light. Hold the pearl so that it is illuminated by rays from the rear and observe the change in intensity of reflected light as the pearl is rotated. This rotation is accomplished most readily if the pearl is mounted on a string or a piece of thin wire. At the position for which the characteristic mother-of-pearl sheen is reflected by the nacre-bead, this sheen is clearly visible shining out from inside the pearl (Fig. 1c). It appears again on rotation of the pearl through 180°. After a little practice the eye catches quickly this phenomenon. Its appearance, which adds to the interest of the pearl, brands the pearl definitely as a cultivated pearl with a mother-of-pearl center.

2. *Test in transmitted light.* The pearl is examined either in air or while immersed in a liquid, such as water; the purpose of the liquid is to reduce to a minimum the amount of light reflected at the surface and thus to render more easily visible any lack of

[3] Optics. Sir David Brewster, pp. 137–149. 1853: A H. Pfund, *The colors of mother-of-pearl.* J. Franklin Inst., 453–464. 1917.

homogeneity within the pearl. As a rule the liquid is unnecessary and is rarely used because it may possibly stain the pearl. The method consists in sending a narrow beam of intense light into one side of the pearl and noting any differences in illumination, along different directions in the opposite half, which are due to a foreign nucleus such as as a mother-of-pearl bead. Adequate illumination is attained by imaging on the pearl an intense light source, such as a pointolite bulb or a small arc or the sun, with the aid of a condensing lens

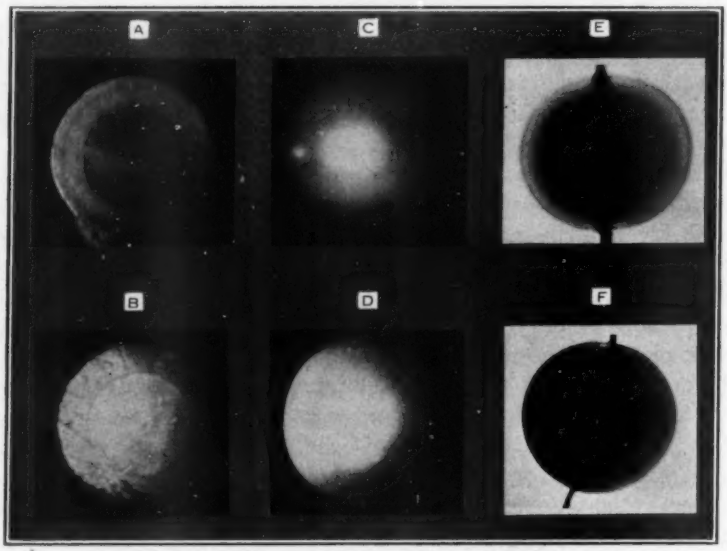

Fig. 1. *A*. Diametral section of cultivated pearl showing mother-of-pearl bead illuminated from the side. Magnification 5×. *B*. Section of the same pearl viewed in reflected light. *C*. Cultivated pearl viewed in reflected light showing on the left the illuminated spot due to the mother-of-pearl sheen. *D*. Natural pearl illuminated from the side. *E*. Cultivated pearl illuminated by strong light from the rear. *F*. Natural pearl photographed under the same conditions of illumination.

(Fig. 2). If possible a vertical beam of light travelling upward is used. To avoid extraneous light, the pearl is placed on a thin sheet of metal directly over a small hole (*c* Fig. 2) drilled through the metal. The hole serves as an aperture, somewhat smaller in diameter than the pearl.[4] The intense beam of light passes through the aperture, impinges on the pearl, and illuminates its interior. The only light that reaches the

[4] A special piece of apparatus for the testing of pearls by this method is now being made available by the Bausch and Lomb Optical Company of Rochester, New York.

observer is that which passes throught the pearl. Any differences in degree of transmission between center and periphery of the pearl are then clearly visible and enable the observer to see the shadow of any foreign nucleus. If the nucleus consists of mother-of-pearl the transparency differences for different directions of transmission through the bead can be observed on rotating the pearl. In natural pearls the central part appears opaque because of the high reflecting power normal to the concentric lamellae; but this central disk is not so large as the bead of a cultivated pearl and does not change its appearance as the pearl is rotated.

Under these conditions of illumination the pearl can be examined by the observer looking at it from any direction, either facing the source of light or at right angles to the incident beam or from any

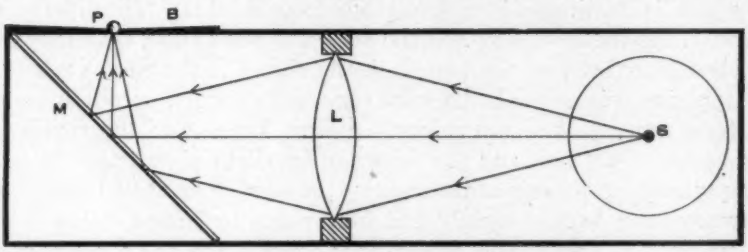

Fig. 2. Simple device for distinguishing cultivated pearls from natural pearls. *S.* strong point source of light; *L.* aspheric condenser lens; *R.* reflecting mirror; *B.* metal plate in which a small hole 3 mm. diameter has been drilled. Above this aperture, which can be made of different size by means of a sliding stop diaphragm, the pearl, *P*, rests.

intermediate position (Fig. 1, e.f). It is advantageous thus to examine the pearl end on and from the side because, as it is turned about, certain differences in homogeneity are more readily seen along one direction than another. Under these conditions any flaws or imperfections in the pearl, whether natural or cultivated, are clearly shown. Cultivated pearls exhibit many imperfections and patches of different reflecting power and degree of transparency. Many natural pearls show minute spots and irregularities, but the best pearls are free from flaws of any kind.

3. *Examination of the walls of the hole drilled through the pearl.* Illuminated by a strong beam of light from the side, the walls of the hole drilled through the pearl exhibit the boundary between the outer pearl substance and the mother-of-pearl nucleus. This is rendered visible not only by a difference in intensity of illumination but also in color; the pearl shells are noticeably blue in color while the nucleus

is tinted yellow. In this examination the pearl is supported on a wire extending into the hole to the center of the pearl. The wire is held between the thumb and first finger in an upright position and the hole is examined with the aid either of a magnifying glass, a microscope, or a binocular microscope. The work of Galibourg and Ryziger[5] has demonstrated that with the aid of a microscope and a suitable mirror it is possible to detect differences in homogeneity of the material exposed along the hole drilled through the pearl. The mirror, which they employ, is the top of a mercury column, like that in a thermometer tube. The mercury is forced up through the hole in the pearl by a delicately adjusted apparatus and the reflections from the top of the mercury column are observed through a strong magnifying system (microscope or binocular). This method is said to be very successful. The pearl is illuminated by a strong light from the side. The difference between the darker center and the enclosing pearl shell, especially at the boundary between the two, is clearly shown in the curved mirror. In applying this method, the writer has had difficulty in obtaining a uniform movement of the mercury column because of the capillary dimension of the hole and the tendency for slight obstructons to bar temporarily the passage of the mercury; in passing an obstruction, the mercury tends to flow rapidly and to advance by jumps rather than smoothly. The apparatus moreover is complicated and for purposes of this sort the handling of mercury is rarely satisfactory.

The following simpler and equally efficient method may serve the same purpose. In place of the mercury column a small bead fused on the end of a pure gold wire is used. A short piece of fine gold wire (0.2 mm. diameter and about 1 cm. long) is satisfactory; the bead is produced by holding the end of the wire in a Bunsen flame for a time sufficient to melt down the tip and form a small bead. The gold bead thus produced is much smoother and presents a more perfect reflecting surface than does a silver or platinum wire bead, or the surface which can be formed by grinding and burnishing the end of a fine steel needle in a lathe. The gold bead can be silver plated if desired. In the writer's experience, however, this is unnecessary. The wire is held stationary in a vertical position with the bead uppermost between the thumb and forefinger, the pearl to be examined is held by the other hand and slid over the stationary wire so that the wire passes through the drilled hole. If desired, the wire and also the pearl can be held by mechanical device and the pearl moved up or down by a screw. The pearl is illuminated by a strong light from the side. During this

[5] The Watchmaker, Jeweler, Silversmith and Optician, pp. 1821–1823. 1922.

operation the reflections from the stationary bead are observed through a low power microscope or binocular magnifying 25 to 50 diameters. The various phenomena described by Galibourg-Ryziger are shown equally well by this method. The preparation of beads of different sizes to fit different holes is a matter of only a few minutes.

This method has the advantage over the first two methods in that it may be used to distinguish between normal pearls and cultivated pearls with a pearl center.

In any case, test by all three methods should be applied, the one to serve as a check on the other. These tests are not time-consuming and in most instances lead to definite results.

4. *Test in ultraviolet light.* Recently C. S. Fox (Journ. Indian Industries and Labor, 1[3]: 235; Chemical News, **125**, 67–68. 1922) has found that in ultraviolet light both natural and cultivated pearls fluoresce, with the difference, however, that the Persian Gulf pearls are opaque to ultraviolet light whereas Japanese pearls, both natural and cultivated, have a translucent opalescence. He considers that because the cultivated pearl has a nucleus which comprises from 0.5 to 0.9 of the total volume of the pearl and which is of inferior material (mother-of-pearl) whereas a natural pearl is made up of concentric layers of pearly substance from center to periphery, the cultivated pearl is an inferior article and is not to be considered in the class with natural pearls. In view of the difficulty in distinguishing cultivated pearls from natural pearls, he proposes that all Japanese pearls, both natural and cultivated, which show a translucent opalescence in ultraviolet light, shall be considered of inferior quality. The writer has repeated the test of Fox with the new fluorescent microscope of the Bausch and Lomb Optical Company and has noted that the translucent opalescence described by Fox is not so clearly and distinctly shown that uncertainty may not arise regarding the kind of pearl under test, whether Indian or Japanese. It would seem unwise to adopt this suggestion because pearls may at some future time be cultivated in the waters of the Persian Gulf and then the rule would fail to accomplish the desired result, and produce confusion worse than ever.

BOTANY.—*A new genus of senecioid composites.* P. A. RYDBERG, New York Botanical Garden. (Communicated by PAUL C. STANDLEY.)

The genus *Clappia*, named after Dr. A. Clapp of New Albany, Indiana, was described by Dr. Gray in the Botany of the Mexican Boundary Survey. Dr. Gray placed the genus in the tribe Helenieae,

but thought that it might be referred to the subtribe Tagetineae. In the Synoptical Flora he transferred it to the subtribe Jaumieae, and was followed by Hoffman in Engler and Prantl's Natürlichen Pflanzenfamilien. When I prepared the manuscript of that subtribe for the North American Flora I was not so well acquainted with the variations displayed in the subtribe Tagetineae, and let it remain in the position given by Gray and Hoffman, though I felt that it was out of place. The bracts of the involucre are striate by black ducts which evidently are to be regarded as elongated resin glands. Such black markings, though very short, are found also on the leaves, especially the reduced upper ones. It is now evident to me that the genus should be transferred to the tribe Tageteae. The other genera of Jaumeanae lack this resinous striation as well as the fimbrillae on the receptacle.

The type of the genus, collected by Berlandier at Laredo, Texas, is rather unsatisfactory, being mostly out of flower, but Hooker illustrated it in his Icones (*pl. 1105*) from better material. The plant was reported by Gray as collected by Havard along the Pecos River and it was found by Rose at Brownsville in 1913 (*no. 18096*). The latter specimens show the characters of the genus very well.

Clappia suaedaefolia was also reported by Wooton and Standley in their Flora of New Mexico,[1] but the specimens on which this record was based do not belong to it and I suspect that it may be the case with Havard's specimens mentioned above. If Wooton and Standley's material is compared with type of *Clappia* or with Rose's specimens of the same, it is evident that the resemblance is only superficial and consists only in the same general habit, and that the former does not even belong to the genus *Clappia*. I was inclined to refer the specimens to the genus *Senecio*, but Dr. Greenman, who knows that genus much better than myself, was not willing to include them and I therefore propose the following new genus.

Pseudoclappia Rydberg, gen. nov.

Shrubs with glabrous, straw-colored or white branches. Leaves linear, subterete, fleshy, alternate or subopposite. Heads radiate, solitary, pedunculed, terminating the branches. Involucre turbinate, without caliculum; bracts about 9, linear, somewhat fleshy, in 2 subequal series. Receptacle naked, alveolate. Ray-flowers 4 or 5, the ligules linear-oblong, 5–7-nerved. Disk flowers about 15, the tube narrow, shorter than and grading into the narrowly somewhat funnelform throat, the 5 lobes short, deltoid. Anthers with deltoid tips. Style-branches subulate-filiform, minutely hairy. Achenes prismatic, 5-ribbed, hispidulous. Pappus of numerous stiff bristles.

[1] Contr. U. S. Nat. Herb. **19**: 719. 1915.

Pseudoclappia arenaria Rydberg, sp. nov.

Clappia suaedaefolia Woot. & Standl. Contr. U. S. Nat. Herb. 19:719. 1915. Not *C. suaedaefolia* A. Gray. 1859.

A low shrub; leaves linear, 1–3.5 cm. long, 1–2 mm. thick; peduncles 2–4 cm. long, with a few scalelike subulate small leaves; involucral bracts glabrous, linear, acute, 8–10 mm. long; ligules yellow, 6–8 mm. long, 2–2.5 mm. wide; disk-corollas about 1 cm. long; achenes blackish, prismatic, 3 mm. long, 1 mm. thick.

NEW MEXICO: White Sands, Otero County, July 20, 1901, *Wooton* (type; U. S. Nat. Herb. no. 739956); Aug. 31, 1904, Wooton *2618;* June 21, 1895, *Wooton.* White Sands, Dona Ana County, July 19, 1897, *Wooton 483.* South Spring, May 2–4, 1903, *Griffiths 4243* (U. S. Nat. Herb. no. *496288,* in part).

The plant can not be included in *Clappia* since it lacks the resinous striation of the bracts and the fimbrillae on the receptacle, and the bristles of the pappus are neither flattened nor paleaceous at the base. It can not be included in *Senecio* since the involucre is without caliculum and its bracts of a different texture, the pappus-bristles are stiffer than is usual in that genus, and the style-branches are distinctly Vernonioid, neither truncate nor with a hair-pencil at the end. The genus should, however, be referred to the tribe Senecioneae, subtribe Senecionanae, notwithstanding the Vernonioid style. A more or less vernonioid style is found also in the genera *Gynura, Emilia,* and *Psacalium.*

BOTANY.—Calderonia *and* Exandra, *two new genera of the family Rubiaceae.* By PAUL C. STANDLEY, U. S. NATIONAL MUSEUM.[1]

During a botanical collecting trip to the Republic of Salvador in 1921–22 the writer obtained imperfect material of two trees of the family Rubiaceae, both of which prove to represent undescribed genera. Both of them had been obtained by earlier collectors, and specimens existed in the National Herbarium, but the early material was too incomplete for satisfactory identification and has remained undetermined until now.

Of the two genera here described the more interesting and better defined is *Calderonia,* of which a complete series of specimens, showing both flowers and fruit from the same tree, has been collected by Dr. Salvador Calderón, of the Chemical Laboratories of the Salvadorean Department of Agriculture. Dr. Calderón is an enthusiastic student of botany and entomology, and has presented to the National Museum an unusually interesting collection of Salvadorean plants, beautifully prepared and consisting of over 1500 specimens, which are of exceptional value because of the vernacular names and full notes upon economic applications which accompany them.

[1] Published by permission of the Secretary of the Smithsonian Institution.

It is with a peculiar sense of pleasure and satisfaction that I am able to associate with one of the important trees of Salvador the name of a valued personal friend who is a true scientist in every sense of the word and who has done so much to make known the flora of one of the Central American countries of which practically no information was available previously. My pleasure in naming this genus is enhanced by the fact that it is thus possible to express, although very inadequately, an appreciation of the generous attentions and courtesies received from Dr. Calderón during a visit of five months to Salvador, attentions which contributed in a large measure toward making those months a delightful experience.

Calderonia Standl., gen. nov.

Trees, nearly glabrous throughout. Leaves opposite, petiolate, large, thin, deciduous. Stipules large, interpetiolar, caducous. Inflorescence terminal, the flowers small, cymose-paniculate, bracteate and bracteolate, sessile or short-pedicellate; hypanthium clavate, terete; calyx very shallowly 5-lobate but ruptured by the expanding corolla, persistent; corolla fleshy-coriaceous, funnelform-campanulate, the tube short, campanulate, the 5 lobes oblong-ovate, obtuse, nearly equaling the tube, glabrous outside, pubescent within, recurved, valvate in bud. Stamens 5, alternate with the corolla lobes, inserted at the base of the tube; filaments stout, pubescent below, exserted; anthers oblong, obtuse, dorsifixed near the base, dehiscent by antrorse slits. Disk annular, fleshy. Ovary 2-celled; style stout, glabrous, exserted, the 2 branches clavate and angulate; ovules numerous, crowded, attached to the septum. Capsule globose, ligneous, 2-celled, loculicidally bivalvate from apex nearly to base, the septum also vertically dehiscent. Seeds numerous, large, horizontal, semiorbicular, compressed, terminating in a thin transparent wing as large as the body, the testa minutely reticulate; embryo large, the radicle minute, the cotyledons oval, thin; endosperm none.

Type species, *Calderonia salvadorensis* Standl.

Calderonia salvadorensis Standl., sp. nov.

A tree, 5–15 meters, high, the trunk slender, with smooth whitish bark; young branchlets minutely puberulent; stipules linear-lanceolate, long-attenuate, about 2 cm. long, glabrous; petioles slender, 2–3 cm. long, minutely puberulent; leaf blades elliptic to oval-elliptic or oblong-obovate, 12–24 cm. long, 5.5–12 cm. wide, acute or short-acuminate, somewhat narrowed to the rounded or emarginate base, thin, puberulent beneath along the nerves, in the axils of the main nerves barbate and domidiate (furnished with small shelters—for parasites?), elsewhere glabrous, the lateral nerves 10–12 pairs; panicles 8–15 cm. long, often leafy below, dense, many-flowered, the rachis minutely puberulent, the flowers mostly sessile; hypanthium glabrous, 3 mm. long; calyx 1.5 mm. long, the lobes rounded, minutely ciliolate; corolla 5 mm. long; filaments about equaling the corolla lobes, the anthers 2.5 mm. long; capsule slightly depressed, about 2 cm. in diameter, with numerous large pale lenticels; seeds (including the wing) about 15 mm. long and 6 mm. wide.

Type (a flowering specimen) in the U. S. National Herbarium, no. 1,151,718, taken from a tree planted in the street in front of the Santa Tecla Railway station, in San Salvador, Republic of Salvador, July, 1922, by Dr. Salvador Calderón (no. 761).

Additional specimens examined:

SALVADOR: San Salvador, December, 1922, *Calderón* 761 (fruiting specimens from the type tree). Tonacatepeque, Departamento de San Salvador, December, 1921, *Standley* 19499. Nahulingo, Departamento de Sonsonate, alt. 220 meters, March, 1922, *Standley* 22052. Sonsonate, alt. 220 meters, March 1922, *Standley* 22312.

GUATEMALA: Patalul, Departamento de Sololá, February, 1906, *Kellerman* 5986.

The genus *Calderonia* belongs to the tribe Condamineeae of the family Rubiaceae. In the key to the genera of this group published a few years ago by the writer,[2] it would run at once to *Picardaea*, a West Indian genus to which it is not closely related. *Calderonia* differs from *Condaminae* in its winged seeds; from *Chimarrhis* in its terminal inflorescence; and from *Rustia* in the dehiscence of the anthers. The absence of endosperm in the seed is probably an important character. The Salvadorean tree appears to represent an unusually well marked genus of the Rubiaceae.

Calderonia salvadorensis is known in Salvador by the vernacular names of *campeche*, *brasil*, and *palo colorado*, and at Sonsonate I was informed that the names *drago* and *sangre de chucho* ("dog's-blood") were applied to it. The names *palo colorado*, *drago*, and *sangre de chucho* doubtless allude to the fact that all parts of the plant quickly assume a reddish tint when cut. This is particularly noticeable in the wood, but the leaves also are often affected the same way in drying.

The wood is said to be of good quality and is employed for building purposes and for firewood. By its peculiar color it is easily recognized. This red coloration is a property of other woods produced by trees of the same family, as, for instance, *Genipa maxonii* Standl., of Panama. Dr. Calderón in a recent letter says: "Lately I saw the wood used for rafters in a country house being built near Sonsonate, and in a building under construction in that city. Some time ago on the shore of Lake Ilopango, at a locality known as Apulo, I saw a large quantity of sawed timbers at least 45 cm. wide and 7 meters long or more, of pink wood, to which the name of *quina* was given. I do not know whether the tree from which they were obtained was the same as my No. 761, but the appearance of the wood was identical. The trees which I have seen are smaller, but in the wild state it would not be strange to find them large enough to give lumber of the dimensions I have described." The name *quina* ("quinine"), it may be remarked, is one often given in Salvador and elsewhere in Central America to Rubiaceous trees because their bitter bark is employed locally in place of the imported quinine.

The tree, Dr. Calderón states, is common in the fincas about San Salvador,

[2] N. Amer. Fl. **32**: 4. 1918.

being grown from seeds brought from the forests of the Department of La Libertad, where it is native. I saw many of the trees planted along the roads in the neighborhood of Sonsonate, and a fine large one in a finca at Tonacatepeque.

Exandra Standl., gen. nov.

Shrubs or trees. Leaves opposite, petiolate, the blades large, thin. Stipules interpetiolar, caducous. Inflorescence terminal, the flowers small, numerous, in paniculate cymes, sessile or short-pedicellate, bracteate and bracteolate; hypanthium clavate, somewhat obcompressed; calyx short, persistent, irregularly 5 or 6-lobate, the lobes triangular, obtuse or acute, thin, about equaling the tube; corolla shortly and broadly funnelform, glabrous within and without, open in bud, the tube broadly obconic, the 5 or 6 lobes nearly obsolete, broadly rounded, recurved in anthesis. Stamens 5 or 6, inserted at the middle of the corolla tube, alternate with the lobes, the filaments stout, long-exserted, pubescent below; anthers oblong, obtuse, dorsifixed near the base, dehiscent by lateral slits. Disk annular, shallowly lobate. Ovary 2-celled; style stout, nearly equaling the stamens, glabrous, deeply bilobate, the lobes oblong, obtuse; ovules numerous.

Type species, *Exandra rhodoclada* Standl.

Exandra rhodoclada Standl., sp. nov.

A shrub or tree, the young branchlets minutely puberulent; stipules about 2 cm. long, attenuate, puberulent; petioles slender, 2.5–4 cm. long subterete, minutely puberulent; leaf blades rounded-ovate or rounded-oval, broadest near the middle, 20–30 cm. long, 16–25 cm. wide, short-acute or acuminate at apex, often somewhat abruptly so, slightly narrowed below and at base shallowly or deeply cordate, thin, glabrous except beneath upon the nerves, there minutely puberulent, the costa slender and salient beneath, the lateral nerves about 11 pairs; panicles short-pedunculate, dense, about 9 cm. long, pyramidal, the rachises fulvous-puberulent; bracts and bractlets lanceolate to triangular, small and deciduous; flowers mostly sessile; hypanthium puberulent, 3 mm. long; corolla 4–5 mm. long, 3.5–4 mm. broad; filaments 5–6 mm. long, the anthers 2 mm. long.

Type in the U. S. National Herbarium, no. 229232, collected between La Venta and Niltepec, Oaxaca, Mexico, altitude 60 meters, July 14, 1895, by E. W. Nelson (no. 2796).

Additional specimens examined:

SALVADOR: Comasagua, December, 1922, *Calderón* 1370. Finca Colima, in the Sierra de Apaneca, Departamento de Ahuachapán, January, 1922, *Standley* 20139.

The Mexican specimen is said to have been taken from a shrub or tree of 2.5 to 4.5 meters, with brownish and green flowers. Both the Salvadorean specimens are sterile but there is little doubt that they represent the same species. They were taken from trees, for which the vernacular names were given as *brasil* and *limpia-dientes*. Dr. Calderón reports that the tree yields lumber of good quality.

The systematic position of the proposed genus is doubtful because of the lack of fruit, but the writer has little hesitation in making the tree the type

of a new genus, since comparison with all the American genera of restricted groups of Rubiaceae, to one of which it must belong, shows that it can not be referred satisfactorily to any of them. The most noteworthy character is to be found in the estivation of the corolla, which is open in all the buds upon the single fertile specimen seen. It is probable, however, that the corolla lobes, theoretically at least, are imbricate in bud, which would make impossible the reference of the genus to the tribe Condamineeae, whose genera it resembles in general appearance. In its aspect it strongly suggsts *Calderonia*, to which the writer at first believed that it must belong, but the floral details of the two trees are quite distinct.

One of the striking features of *Exandra rhodoclada* is the red coloration assumed by the wood upon exposure to the air, a character which it shares with *Calderonia*. This coloration is perceptible also in the petioles and in the veins of the leaves after drying.

In connection with the descriptions of these two new genera there may be recorded the rediscovery of a plant described in this Journal[3] by myself a few years ago as a new genus of Rubiaceae, under the name *Blepharidium guatemalense*. The description was based upon a specimen collected in forest along the Saklak River below Secanquím, Alta Verapaz, Guatemala, in 1905 by Mr. H. Pittier. During May, 1922, I spent several weeks collecting about Quiriguá, Guatemala, and on the very first morning that I went out collecting this plant was found and recognized. It was seen several times in the vicinity, but the season was a little too early for obtaining good material, since at this time, the end of the dry season, the flowers were not fully developed. *Blepharidium guatemalense* is a shrub of two to three meters, with few branches and large (sometimes 45 cm. long), handsome, glossy leaves. It occurs sparingly upon the hills back of the hospital at Quiriguá at the edge of the pine forest with which their summits are clothed, growing in the dense thickets which are characteristic of the cohune (*Attalea cohune*) and pine ridges. The vegetation here bears a striking resemblance, both in general appearance and in composition, to that of the pinelands of southwestern Florida.

[3] 8: 59. 1918.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

171ST MEETING

The 171st meeting of the ACADEMY was held jointly with the Philosophical Society of Washington in the Assembly Hall of the Cosmos Club the evening of Thursday, December 21, 1922. Dr. H. A. CLARK, Physicist of the Taylor Instrument Companies, Rochester, New York, delivered an address entitled, *The manufacture of thermometers.*

In the drawing of capillary tubing for thermometers, the workman fashions a mass of hot glass of approximately taffy-pulling consistency, on the end of a blowpipe. In this mass (12 to 16 inches long and 4 to 6 inches in diameter), the relative dimensions of the various parts in a cross section (such as the two diameters of an oval bore, if it is oval, and the various outside diameters if the tube is not cylindrical) are the same as in the completed tubing. It is then drawn mechanically to a length of about 180 feet, the final diameter depending upon various factors including rate of drawing.

To make a "chemical" thermometer, the workman starts with a piece of capillary cut to length, the area of bore of which has been carefully determined at both ends with a high power microscope. If it is to be a precision thermometer, the bore has, in addition, been calibrated with a mercury thread. A short piece of large-bore thin-walled tubing is sealed on for a bulb and its end drawn to a capillary through which mercury flows into the bulb, partly filling it, as it cools. The end of the bulb is sealed off, the mercury inside boiled to expel air, and the entire system now fills as it cools with the upper end of the stem under mercury.

The upper end is now sealed off with a large "false chamber" into which the bulb filling flows when bulb and stem are put into an electric oven for annealing, temperature being carefully controlled.

After annealing, excess mercury is driven into the false chamber and the stem is melted off just below, in such a way that the capillary space above the mercury column is evacuated or is filled with nitrogen, according to the range desired.

The "tube," so called, is now ready for a scale. For this purpose it is "pointed" by locating the mercury surface in the capillary at each of several known temperatures, by means of a fine scratch on the stem. To do this, the "tube" is immersed in well-stirred "baths" of various liquids, the temperature of each being determined with a standard thermometer. The temperature points chosen for pointing depend on the accuracy desired, as well as the range.

The tube is coated with wax and an automatic engraving-machine cuts the graduations, the spacing being automatically varied as required by the slight unavoidable non-uniformity of bore. Dipping into hydrofluoric acid, cleaning off acid and wax, and filling graduations with pigment make the thermometer finally complete.

The many other types of mercury-in-glass thermometers, clinical, industrial and others, pass through the above processes as well as others, depending upon the type. Still other types, consisting of liquid-in-metal bulbs and flexible metallic capillaries, much used in industry, cannot be here described for lack of space. (*Author's abstract.*)

172D MEETING

The 172d meeting of the ACADEMY, the 25th annual meeting, was held at the Administration Building of the Carnegie Institution of Washington the evening of Tuesday, January 9, 1923. The meeting was called to order by Vice-President CRITTENDEN, who called upon the retiring President, W. J. HUMPHREYS, to give his address entitled, *The murmur of the forest and the roar of the mountain.* This has since been published in the Journal of the Academy (**13**:49–64. February 19, 1923).

Following a brief intermission after the address, the annual business meeting of the Academy was held. The minutes of the 24th annual meeting were read and approved. The Corresponding Secretary, FRANCIS B. SILSBEE, reported briefly on the activities of the Academy during the year. On January 1, 1923, the membership consisted of 6 honorary members, 3 patrons, and 563 members, one of whom was a life member. The total membership was 572, of whom 355 reside in or near the District of Columbia, 201 in other parts of the United States, and 7 in foreign countries. Thirteen resignations were accepted during the year, of which two were of resident members, and the Academy lost by death the following members: CHARLES BASKERVILLE, ALEXANDER GRAHAM BELL, EDWARD K. DUNHAM, WILLIAM FREAR, HENRY MARION HOWE, CHARLES W. WAIDNER. During the year the Board of Managers held nine meetings. The decision of the Academy to discontinue the practice of attempting to print in the JOURNAL abstracts of scientific papers emanating from Washington was explained, the principal objections to the former custom being that the collection of abstracts was by no means complete, and that such abstracting service was better covered by special journals devoted to obtaining complete abstracts of all articles in their respective fields.

The report of the Recording Secretary, WILLIAM R. MAXON, was read. There were held during the year 9 public meetings, several of them jointly with one or more affiliated societies, at which illustrated addresses were delivered. The titles and dates and the places of publication of the addresses were stated.

The report of the Treasurer, R. L. FARIS, showed total receipts of $5,609.12, and total disbursements of $4,916.17; the cash balance in hand December 31, 1922, was $2,671.47. Investments of the Academy have a total par value of $15,036.37. The cost of maintaining and printing the Journal in 1922 was $3,579.26, a slight increase over 1921.

The report of the Auditing Committee, consisting of OSCAR S. ADAMS, E. F. MUELLER, and S. J. MAUCHLY was read, and the reports of the Treasurer and the Auditing Committee were accepted.

The report of the Editors of the Journal was read by SIDNEY PAIGE, the senior Editor. In general, the editorial policy of the Board had remained as in 1921, the changes made in composition and in size of page having been continued. Also, the cost of producing illustrations had been borne by the authors, as previously. Volume 12 consists of 486 pages, as against 537 published in Volume 11. Of original papers there were 52, one less than in 1921. The departments of Proceedings and Scientific Notes and News were maintained, but the publication of abstracts had been discontinued early in the year, as explained above.

The Committee of Tellers reported that the following officers had been elected for for 1923: *President,* T. WAYLAND VAUGHAN; *Non resident Vice-Presidents,* D. T. MCDOUGAL, W. F. G. SWANN; *Corresponding Secretary,*

F. B. SILSBEE; *Recording Secretary*, WILLIAM R. MAXON; *Treasurer*, R. L. FARIS; *Managers, Class of 1926*, H. L. SHANTZ, WILLIAM BOWIE.

The following Vice-Presidents, nominated by the affiliated societies, were then elected: *Archaeological Society*, A. H. CLARK; *Biological Society*, A. S. HITCHCOCK; *Botanical Society*, W. E. SAFFORD; *Chemical Society*, W. M. CLARK; *Institute of Electrical Engineers*, A. R. CHENEY; *Society of Engineers*, R. H. DALGLEISH; *Entomological Society*, S. A. ROHWER; *Society of Foresters*, G. B. SUDWORTH; *National Geographic Society*, FREDERICK V. COVILLE; *Geological Society*, W. C. ALDEN; *Medical Society*, L. H. REICHELDERFER; *Philosophical Society*, W. P. WHITE.

At 10:20 the meeting adjourned.

173D MEETING

The 173d meeting of the ACADEMY was held jointly with the Geological Society of Washington in the Assembly Hall of the Cosmos Club the evening of Wednesday, January 24, 1923. Dr. M. E. DE MARGERIE, Director of the Geological Survey of Alsace-Lorraine, delivered an illustrated address entitled, *The structure of the Alps.*

174TH MEETING

The 174th meeting of the ACADEMY was held in the Assembly Hall of the Cosmos Club the evening of Thursday, February 15, 1923. Mr. W. D. COLLINS, of the U. S. Geological Survey, delivered an address entitled, *The industrial aspects of modern methods of water purification.*

Successful manufacturing is dependent on the chemical character of the water available for use in the various processes. The methods of water purification that are necessary for some supplies have a profound influence on the industrial value of the treated water. This has been the experience of many manufacturers who have been compelled to use water from a treated supply and attempt to duplicate the production of a plant using a water so free from mineral matter and organic pollution that it required no treatment.

The development of industry in the United States in the last fifty years has resulted in the movement of the center of industrial activity from New England, where pure water has been abundant, towards the middle west, where practically all the water available for public supplies requires purification. The demand for larger and larger supplies which must be taken from surface sources and the increasing pollution of these surface sources make necessary more and more complicated methods of treatment. While the purification makes some waters better for industrial use than t ey were before treatment, there are many instances where the treatment necessary to make a water safe to drink renders it quite unsatisfactory for some industrial uses. Serious losses have resulted from seemingly insignificant causes, such as the well known "iodoform" odor in some chlorinated waters, or from the excess or deficiency of carbon dioxide resulting from treatment with alum or lime. The person responsible for the successful operation of a manufacturing plant where the chemical character of the water used has an effect on the product must watch carefully the operation of the water purification plant, if he is using the water from a public supply that is purified by one of the more complicated methods of treatment. (*Author's abstract.*)

175TH MEETING

The 175th meeting of the ACADEMY was held jointly with the Philosophical Society of Washington in the Assembly Hall of the Cosmos Club the evening of Saturday, March 10, 1923. Prof. A. SOMMERFELD of Munich, delivered an address on *Evidence for the theory of relativity afforded by atomic physics.*

Two branches of modern physics stand in the center of scientific interest, the theory of relativity and the theory of atomic structure. They came together, as the speaker showed in 1916, in the theory of the fine structure of certain spectral lines.

The theory of relativity (Einstein, 1905 and 1915) is a new foundation of our general notions of space, time, matter, and gravitation, based on observational facts. The mass of an electron, for example, as well as length, time, and energy, is dependent on the relative velocity of the electron with respect to the observer. The theory of atomic structure (Bohr, 1913) is based on the notion of the nuclear atom (Rutherford, 1911) and on the theory of quanta (Planck, 1900). The electrons revolve around the nucleus, like the planets in the solar system around the sun. In the simplest atoms of hydrogen and of ionized helium we have a Keplerian motion: one electron revolving around the nucleus. Bohr succeeded in computing the wave lengths of the spectral lines of these elements and in revealing the laws of spectra, widely different from the laws of the oscillations of the usual mechanical systems. The wave-lengths are given by the energy differences of the atom in its initial and final states.

According to the theory of quanta, a certain state of the atom corresponds to a certain number of electronic orbits, either circular or elliptical. In the helium line $\lambda = 4686$, e.g. the initial state of the atom corresponds to four different orbits, the final state to three. These four different initial orbits, as well as the three different final ones, have the same energy, according to the classical mechanics of Newton. Therefore, all the $4 \times 3 = 12$ transitions give the same energy difference and produce the same spectral line.

But Newton's mechanics are only a first approximation; the real mechanics are Einstein's. According to the relativistic increase of the electronic mass with increasing velocity, the energy of the four initial orbits is slightly different as well as the energy of the three final orbits. So we get 12 components very close together, of a so-called fine structure. The photographs taken by Paschen in 1916 are projected; they prove themselves to be in best agreement with the prediction of the theory.

Fine structure components of the same character occur in the X-ray spectra of all elements; they show that the same circular and elliptical orbits and the same relativistic increase in the mass of the electron occur in the inner parts of all elements. (*Author's abstract.*)

WILLIAM R. MAXON, *Recording Secretary.*

PHILOSOPHICAL SOCIETY OF WASHINGTON

883D MEETING

The 883rd meeting was held in the Cosmos Club Auditorium on Saturday, April 7, 1923. It was called to order at 8:15 p.m. by President WHITE with 42 persons in attendance.

Owing to some experiments with liquid hydrogen which were in preparation by Dr. KANOLT, the reading of minutes of previous meetings was deferred until later in the evening.

The first paper on *Liquid and solid hydrogen* was presented by Dr. C. W. KANOLT. The paper was discussed by Messrs. HEYL, PAWLING, LITTLEHALES, HAWKESWORTH, CHANEY, amd HUMPHREYS.

Author's abstract: Liquid hydrogen was first obtained by Dewar in England about 25 years ago, and since then it has been produced in several laboratories. Although the method employed is fairly simple in theory, there have been some practical difficulties involved. The purpose of the work at the Bureau of Standards has been, first to make it possible to obtain readily at the bureau fairly large quantities of liquid hyrogen for experimental purposes, and, second, to study the difficulties of the process in order to make it easier for other laboratories to produce the liquid.

The principal difficulty has resulted from the influence of small quantities of air in the hydrogen. The air is frozen in the hydrogen expansion valve and soon clogs it. A proportion of air too small to be found by ordinary methods of gas analysis may still be sufficient to produce clogging. However a new method of determining very small quantities of nitrogen, the most troublesome impurity, in hydrogen has been found, and this has greatly facilitated the investigation and elimination of sources of contamination. The hydrogen employed is generated electrolytically in the laboratory. The liquefier in use produces two liters of liquid per hour and little difficulty is now experienced in its operation.

Solid hydrogen can be obtained by evaporating the liquid in a partial vacuum produced by a pump of sufficiently large capacity, and as the vapor pressure at the freezing point is relatively high, this operation is not difficult.

Liquid hydrogen was exhibited at the meeting and with it air from the room was liquefied and frozen.

President WHITE made announcement of the meetings of the American Geophysical Union to be held at the Administration Building of the Carnegie Institution of Washington on April 17 to 19.

Captain N. H. HECK presented a paper on *The relation of seismology to geodesy and tides.* The paper was illustrated with lantern slides, and was discussed by Messrs. HUMPHREYS, L. H. ADAMS, and BOWIE.

Author's abstract: A brief introductory statement shows what is being done in the United States in the study of Seismology, and the relation of the Coast and Geodetic Survey, which is doing the principal work in geodesy and tides, to this subject.

The need for better instruments, operation, and time control is pointed out. The important cooperative earthquake investigation in California by the Carnegie Institution of Washington, the California Universities, the Geological Survey, and the Coast and Geodetic Survey has brought out the necessity for precise triangulation and levels in seismological work, to determine whether or not surface shifts have occurred. Observations in Japan and elsewhere show clearly that such work should be carried on in earthquake regions.

The possibility of such shifts along the coasts, due to submarine earthquakes, makes the observation of such earthquakes of special importance. The magnetic observatories of the United States, though placed entirely with regard to magnetic work, are exceptionally well located for the observation of submarine earthquakes, four of them being in regions where major earthquakes have occurred.

Submarine earthquakes are the cause of the so-called tidal waves, destructive nearby, and often causing long continued fluctuations at a distance. Tidal records of the Chilean earthquake tide and of the recent

tidal wave at Hilo, Hawaii, are of special interest. The automatic tide-guage records at twenty stations are now regularly examined for abnormalities due to earthquakes.

Possible relations between the theory of isostasy and earthquakes are pointed out. Isostasy indicates that earthquakes occur above the depth of compensation.

Dr. J. E. IVES presented a paper on *The nature of the illumination used by engravers of steel plates.* The paper was discussed by Mr. HAWKESWORTH.

Author's abstract: The engraver on steel works on highly polished steel plates which are used in the printing of pictures, postage and revenue stamps, paper money, certificates of stock and bonds. Since the lines cut into the steel are visible only by the shadows cast by the edges of their grooves or depressions, or because their surfaces are inclined at such angles that they are in shadow or do not reflect light falling upon them, the best results are obtained by using an illumination which is diffuse with a predominating direction downwards and towards the worker, and which produces a uniform, or nearly uniform, brightness of the whole surface of the plate. This is, in practice, obtained by using a screen of translucent material such as tracing cloth, tracing paper, or tissue paper, placed between the source of the illumination, natural or artificial, and the plate, so that the image of the tracing cloth is reflected in the plate. The screen is usually about 30 inches square and inclined at an angle of about 45° to the plate. The reflected image of the illuminated tracing cloth makes the polished surface of the steel look like a sheet of white paper. On such a surface the lines cut into the steel can be clearly seen. If such a screen is not used there will, in general, be bright and dark areas on it, and where the surface is dark the lines cut into the surface cannot be seen. Also the contrast between the bright and dark areas on the plate produces more or less glare.

Measurements were made of the illumination on the plates, of the brightness of the screens, and of the brightness of the surface of the plates. Study of the results obtained leads to the conclusion that the brightness of the surface of the screen should be as uniform as possible. For natural illumination an uninterrupted north sky light is the best, and is much better than light from south windows, since the latter is very variable, varying from bright sunshine to cloudiness. If the screen is illuminated artificially by one or more electric lamps, the light from the lamps should be so arranged that it is spread uniformly over the screen. It was found that a non-uniform illumination of the screen produced discomfort in the eyes of the workers. Artificial illumination, besides being uniformly distributed over the screen, should also be of sufficient intensity.

The results recorded in this paper were obtained in connection with investigations on this subject made recently by the office of Industrial Hygiene and Sanitation of the U. S. Public Health Service.

884TH MEETING

The 884th meeting was held jointly with the Washington Academy of Sciences and the Chemical Society of Washington in the Auditorium of the Interior Building at 8:30 p.m. on Tuesday, April 17, 1923.

Papers were presented by Dr. F. G. DONNAN, Professor of Chemistry, University College, London, and by Dr. JAMES C. IRVINE, Principal and Vice-Chancellor, University of St. Andrews, on their own recent researches in chemistry.

885TH MEETING

The 885th meeting was held jointly with the Washington Academy of Sciences and the Geological Society of Washington in the Auditorium of the Interior Building at 8:15 p.m. on Wednesday, April 18, 1923.

The following papers on the Taylor-Wegener Hypothesis were presented:

(1) FRANK B. TAYLOR—*The lateral migration of land masses.*

(2) R. A. DALY—*A critical review of the hypothesis.*

(3) W. D. LAMBERT—*The mechanics of the hypothesis.*

After the completion of the third paper, the hour was so late that the fourth paper by F. E. WRIGHT on *Report of the symposium at the meeting of the British Association* was not called for.

J. P. AULT, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Dr. P. S. EPSTEIN, of the California Institute of Technology, lectured at the Bureau of Standards Physics Club, Saturday, June 2, on *The principle of correspondence or the relation of the quantum theory to classical mechanics.*

Messrs. A. H. BROOKS and T. WAYLAND VAUGHAN of the U. S. Geological Survey, and N. M. FENNEMAN of the National Research Council and H. E. GREGORY of Yale University, both associated with the Geological Survey, will attend the Pan-Pacific Congress in Australia in August as official delegates of the Government.

Dr. N. L. BOWEN, petrologist, of the Geophysical Laboratory, Carnegie Institution of Washington, is spending the summer studying the igneous rocks of England, Scotland, Norway, and Sweden.

Dr. F. C. COOK, of the Bureau of Chemistry, U. S. Department of Agriculture, died at Dallas, Texas, on June 19, 1923, in his forty-sixth year. He was born at Litchfield, Connecticut, July 14, 1877. Dr. Cook had been connected with the Bureau of Chemistry since 1903. His scientific studies and publications were concerned with metabolism, enzymes, insecticides, fungicides, etc. He was a member of the ACADEMY, American Chemical Society, and several local and foreign societies.

Mr. A. B. FATH has resigned from the U. S. Geological Survey and has joined the staff of the Vacuum Oil Company. He will be in Europe for the next few months.

Dr. ALES HRDLICKA, of the Department of Anthropology, U. S. National Museum, has sailed for Europe to take charge of a party of American scientists who will study during the summer the prehistoric remains in England, the Island of Jersey, France, Belgium, Germany, Czechoslovakia, and Croatia.

Dr. GEORGE M. KOBER, dean of the medical school of Georgetown University for the last thirty-two years, received the degree of doctor of letters at the 124th commencement exercises of the University on June 11.

Mr. E. S. LARSEN, Jr., has been appointed professor of petrography at Harvard University and will relinquish his work as chief of the section of petrography of the U. S. Geological Survey on September 1.

Mr. W. R. MAXON sailed from New York May 15 for the purpose of making botanical collections in Central America, in cooperation with the U. S. Department of Agriculture, which is sending an expedition for the investigation of the rubber resources of that region.

Dr. F. L. RANSOME, of the U. S. Geological Survey, has accepted an appointment as professor of geology and head of the department at the University of Arizona, Tucson, for the coming academic year. He has not severed his connection with the Geological Survey, and his stay in Arizona is indefinite.

Dr. B. COLEMAN RENICK, graduate of Chicago University and recently connected with the teaching staff of the University of Iowa, has been appointed assistant geologist in the ground water division of the U. S. Geological Survey and will begin work in Montana July 1.

Messrs. E. S. SHEPHERD and PAUL STOUTENBURGH, of the Geophysical Laboratory, Carnegie Institution of Washington, are making a chemical field study of differentiated igneous rocks in Montana and Utah during the summer months.

Dr. EDWARD WOLESENSKY has been appointed associate chemist on the investigation of synthetic tanning materials, at the U. S. Bureau of Standards, from June 11, 1923. He has recently been engaged in research and development work on dyes and intermediates and during the war did research work at the American University.